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U S NAVAL PROVING GROUND
DAHLGREN, VIRGINIA

REPORT NO. 964

FRAGMENTATION CHARACTERISTICS

18th Partial Report

FRAGMENTATION TEST OF
2"75 ROCKET HEADS

FINAL Report

Copy No. 2

Task
Assignment MPG-Re3d-418-1-52
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NAVY DEPT.

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MPG REPORT NO. 964

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NPG REPORT NO. 964

U. S. NAVAL PROVING GROUND
DAHLGREN, VIRGINIA

Eighteenth Partial Report

on

Fragmentation Characteristics

Final Report

on

Fragmentation Test of

2875 Rocket Heads

NAVY RESEARCH SECTION
SCIENCE DIVISION
REFERENCE DEPARTMENT

MAY 12 1952

Project No.: NPG-Re3d-418-1-52
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WPG REP CRT NO. 964

Fragmentation Test of 2475 Rocket Heads

PART A

SYNOPSIS

1. This test was conducted to obtain the fragmentation characteristics of the 2475 Air to Air Folding-Fin Rocket (AAFFR).
2. The HBX-1 loaded 2475 AAFFR when detonated statically produced:
 - a. relatively fine fragments
 - b. an average median fragment velocity of 3780 ft./sec. and
 - c. an average of 745 fragment hits in total polar angle zone 55°-115°, with the heaviest concentration in zone 95°-100°.

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NPG REPORT NO. 964

Fragmentation Test of 2075 Rocket Heads

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Fragmentation Test of 2875 Rocket Heads

PART B

INTRODUCTION

1. AUTHORITY:

This test was authorized by reference (a) and conducted under Task Assignment NPG-Re3d-418-1-52, reference (b).

2. REFERENCES:

- a. BUORD Conf ltr S78-1(119) Re3d-ANB:hm Ser 25820 of 18 Sep 1951
- b. BUORD Restr ltr NP9 Re3d-ANB:hm of 4 Aug 1951
- c. NOTS Conf NAVORD Report 1263, NOTS 329 of 6 Oct 1950

3. BACKGROUND:

Reference (c) reported on the details of the 2875 Air to Air Folding-Fin Rocket (AAFFR) which has a high explosive head and is intended to be used by fighter and interceptor aircrafts in attacks against other aircraft. Reference (a) requested the Proving Ground to obtain fragmentation data for this rocket. The results are reported herein.

4. OBJECT OF TEST:

This test was conducted to obtain the fragmentation characteristics of the 2875 Air to Air Folding-Fin Rocket (AAFFR).

5. PERIOD OF TEST:

a. Date Project Letter	18 September 1951
b. Date Necessary Material Received	19 November 1951
c. Date Commenced Test	11 December 1951
d. Date Test Completed	4 January 1951

6. REPRESENTATIVE PRESENT:

This test was witnessed in part by Mr. F. R. Donoghue representing the Bureau of Ordnance.

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Fragmentation Test of 2875 Rocket Heads

PART C

DETAILS OF TEST

7. DESCRIPTION OF ITEM UNDER TEST:

2875 AAFRR Rockets having HBX-1 loaded MK 2 Rocket Heads and empty Mod 103XE-SF Rocket Motors. The heads were assembled with EX 100 Mod 0 point detonating fuzes which were modified by the Proving Ground for static detonation. The loaded heads with the fuze weighed $6.30 \pm .05$ lbs. and the empty motors weighed $4.0 \pm .05$ lbs. totaling $10.3 \pm .1$ lbs. for the rounds assembled for static detonations. The filler (HBX-1) for the heads weighed 1.4 lbs.

8. PROCEDURE:

The twenty (20) rockets were detonated for the following information:

5 rounds for fragment mass distribution data,

5 rounds for fragment velocity data, and

10 rounds for fragment space distribution data.

a. The determination of fragment mass distribution was conducted in a sawdust-filled chamber. Each rocket was supported on its side in a cane fiberboard box. After each detonation, the sawdust was sifted and the fragments collected with the head fragments and the motor fragments separated and classified separately.

b. Fragment velocity measurements were obtained by the usual high speed photographic technique, using a 35mm Fastax camera. Fragment velocities obtained are the mean velocities over the first 30.6 feet of travel of beam spray (polar angle 75° to 105°) fragments,

c. Fragment space distribution measurements were made in an arena consisting of a complete circle twenty (20) feet in radius. The arena panels were $1/8$ " mild steel plate, five (5) feet high and marked in 5° zones about the axis of the rocket with the nose pointed toward 0° . The center of gravity of the rocket head coincided with the arena center. Complete fragment penetrations of the panels were counted.

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Fragmentation Test of 2875 Rocket Heads

9. RESULTS AND DISCUSSION:

a. Mass Distribution

Photographs of the fragment mass distribution data are shown in Figures 3 to 7 inclusive and are tabulated in Table III. The data are summarized as follows:

5 ROUND AVERAGES

Rocket	NO. FRAGMENTS IN VARIOUS WEIGHT GROUPS					
	5/8-2 1/2	2 1/2-5	5-10	10-20	20-30	320-640
	grams	grams	grams	grams	grams	grams
Head	773	125	44	4	0	0
Motor	46	14	15	10	10	1*

* The largest motor fragment averaged 503 grams.

The fine fragmentation of the rocket head can be attributed to the large explosive charge weight (1.4 lbs.) for a 2875 diameter head.

b. Fragment Velocity

Detailed fragment velocity data are listed in Table II. The average median beam spray velocity of four rounds was 3780 ft./sec. The fifth round was oriented before detonation in such a way to obtain the velocity of the largest motor fragment by camera. This fragment could not be distinguished on the film but from the location of this fragment on the rounds fired in the field, its velocity is estimated to be in the order of 200 ft./sec.

c. Space Distribution

Detailed space distribution data are listed in Table I and the average fragment hits are summarized as follows:

* 9 ROUND AVERAGES

Polar Zone	Hits on Panels	Hits on Sphere
0°-55°	0	0
55°-115°	30	745
115°-155°	0	0
155°-180°	3	8
Total	33	753

* Ten (10) rounds were detonated, one of which detonated low order. The other nine (9) rounds detonated high order.

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Fragmentation Test of 2875 Rocket Heads

As noted from the above data, practically all hits were in zone 55°-115° with the heaviest concentration in zone 95°-100°. Many of the motor fragments struck the 1/8" mild steel panels causing silvery splashes on the steel without ever denting the panels.

PART D

CONCLUSIONS

10. The HBX-1 loaded 2875 AAFFR when detonated statically produced:
 - a. relatively fine fragments
 - b. an average median fragment velocity of 3780 ft./sec. and
 - c. an average of 745 fragment hits in total polar zone 55°-115° with the heaviest concentration in zone 95°-100°.

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Fragmentation Test of 2075 Rocket Heads

The tests upon which this report is based were conducted by:

V. PHILIPCHUK, Fragmentation Battery Officer,
Fragmentation Division,
Terminal Ballistics Department

This report was prepared by:

V. PHILIPCHUK, Fragmentation Battery Officer,
Fragmentation Division,
Terminal Ballistics Department

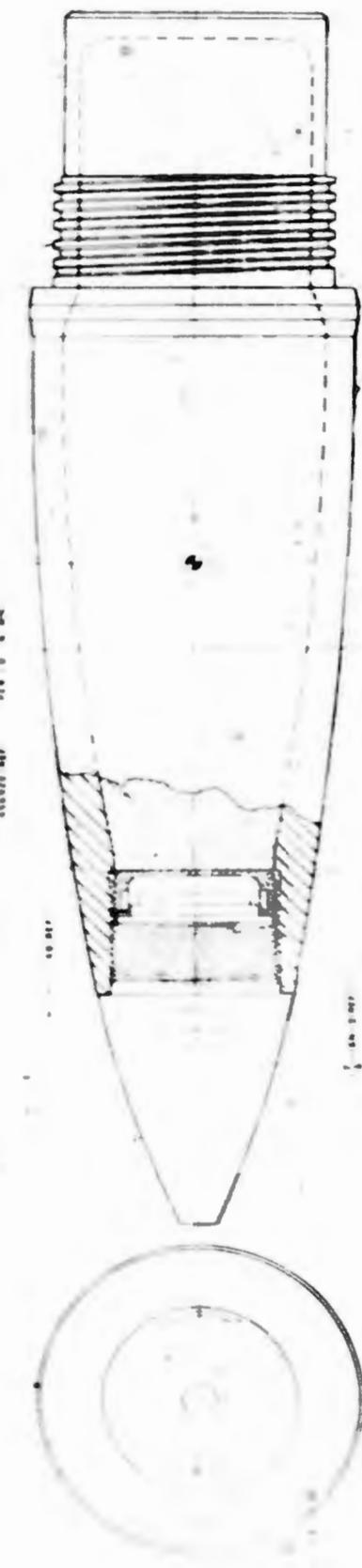
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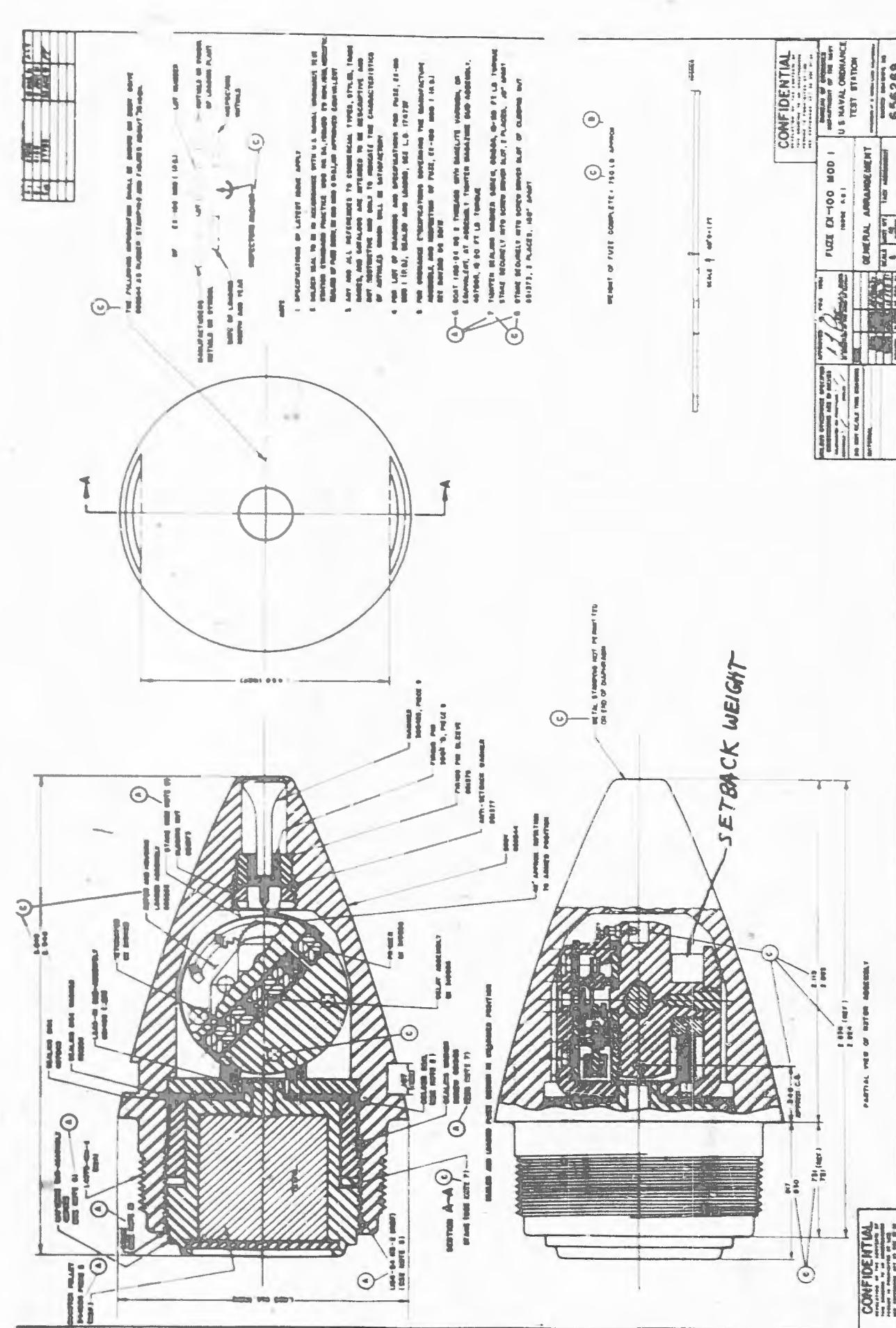
6/21/66
C. T. MAURO
Captain, USN
Ordnance Officer
By direction

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Fragmentation Test of 2875 Rocket Heads

TABLE I

SPACE DISTRIBUTION DATA

20' Radius Space Arena 12 December 1951, 2875 Rockets (Rd. 1)
'1/8" MS panels 5" high 2 January 1952, 2875 Rockets (Rds. 2-9)
9 Rounds Fired

<u>Zone, Degrees</u>	<u>Rd. 1</u>			<u>Rd. 2</u>			<u>Rd. 3</u>		
	<u>R.</u>	<u>L.</u>	<u>Avg.</u>	<u>R.</u>	<u>L.</u>	<u>Avg.</u>	<u>R.</u>	<u>L.</u>	<u>Avg.</u>
0-5									
5-10									
10-15									
15-20									
20-25									
25-30									
30-35									
35-40									
40-45									
45-50									
50-55									
55-60		1	0.5						
60-65							1		0.5
65-70							1		0.5
70-75	1		0.5				1		1
75-80	2	5	3.5	1	2	1.5	1	2	1.5
80-85	4	1	2.5	4	3	3.5	2	1	1.5
85-90	5	3	4	2	3	2.5	1	2	1.5
90-95	6	8	7	7	4	5.5	1	3	2
95-100	10	6	8	12	9	10.5	6	5	5.5
100-105	3	3	3	3	2	2.5	3	1	2
105-110	1		0.5						
110-115									
115-120									
120-125									
125-130									
130-135									
135-140									
140-145									
145-150									
150-155									
155-160									
160-165					1	0.5			
165-170	2	1	1.5	1		0.5			
170-175	1		0.5	2	1	1.5	1		0.5
175-180	1		0.5	2		1			0.5

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Fragmentation Test of 2875 Rocket Heads

TABLE I (Continued)

20' Radius Space Arena 12 December 1951, 2875 Rockets (Rd. 1)
1/8" MS panels 5" high 2 January 1952, 2875 Rockets (Rds. 2-9)
9 Rounds Fired

<u>Zone, Degrees</u>	<u>Rd. 4</u>			<u>Rd. 5</u>			<u>Rd. 6</u>		
	<u>R.</u>	<u>L.</u>	<u>Avg.</u>	<u>R.</u>	<u>L.</u>	<u>Avg.</u>	<u>R.</u>	<u>L.</u>	<u>Avg.</u>
0-5									
5-10									
10-15									
15-20									
20-25									
25-30									
30-35									
35-40									
40-45									
45-50									
50-55									
55-60	1		0.5						
60-65		1	0.5					1	0.5
65-70									
70-75	1		0.5	1		0.5			
75-80	3	2	2.5		1	0.5	2	2	2
80-85	1	1	1	6	3	4.5	3	1	2
85-90	8	6	7	3	7	5	8	1	4.5
90-95	10	3	6.5	7	3	5	7	7	7
95-100	13	10	11.5	10	10	10	9	6	7.5
100-105	1	2	1.5	6	5	5.5	5	4	4.5
105-110					1	0.5			
110-115		1	0.5						
115-120									
120-125									
125-130									
130-135									
135-140									
140-145									
145-150									
150-155									
155-160									
160-165				1		0.5			
165-170				1		0.5			
170-175				2		1			
175-180	2	1					1		0.5

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Fragmentation Test of 2875 Rocket Heads

TABLE I (Continued)

20' Radius Space Arena 12 December 1951, 2875 Rockets (Rd. 1)
 1/8" MS panels 5" high 2 January 1952, 2875 Rockets (Rds. 2-9)
 9 Rounds Fired

Zone, Degrees	Rd. 7			Rd. 8			Rd. 9		
	R.	L.	Ave.	R.	L.	Ave.	R.	L.	Ave.
0-5									
5-10									
10-15									
15-20									
20-25									
25-30									
30-35									
35-40									
40-45									
45-50									
50-55									
55-60	1	0.5					1	1	1
60-65	1.	0.5		2	1		1	1	0.5
65-70									
70-75	1	1	1	1	2	1.5	1	1	1
75-80	2	1	1.5	2	2	2	5		2.5
80-85	4	2	3	5	3	4	5	2	3.5
85-90	2	4	3	9	9	9	4	2	3
90-95	7	9	8	10	5	7.5	11	6	8.5
95-100	10	11	10.5	11	9	10	12	12	12
100-105	8	4		4	1	2.5	5	3	4
105-110									
110-115		1	0.5						
115-120									
120-125									
125-130									
130-135									
135-140									
140-145									
145-150									
150-155									
155-160							1	0.5	
160-165							1	0.5	
165-170					1	2	1.5		
170-175	1	0.5		4	3	3.5			
175-180	1	0.5		1		1.5	1	0.5	

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NPC REPORT NO. 964

Fragmentation Test of 2W75 Rocket Heads

TABLE I (Continued)

20° Radius Space Arena 12 December 1951, 2W75 Rockets (Rd. 1)
1/8" MS panels 5" high 2 January 1952, 2W75 Rockets (Rds. 2-9)

9 ROUND AVERAGES

<u>Zone, Degrees</u>	<u>Average Impacts Per 5° Zone on Panels</u>	<u>Average Impacts Per Total 5° Zone</u>	<u>Average Impacts Per Unit Solid Angle</u>
0-5			
5-10			
10-15			
15-20			
20-25			
25-30			
30-35			
35-40			
40-45			
45-50			
50-55			
55-60	0.2	4	9
60-65	0.3	7	14
65-70	0.2	5	9
70-75	0.7	17	30
75-80	1.9	47	88
80-85	2.8	70	130
85-90	4.4	111	200
90-95	6.3	159	290
95-100	9.5	240	440
100-105	3.3	81	152
105-110	0.1	2	5
110-115	0.1	2	5
115-120			
120-125			
125-130			
130-135			
135-140			
140-145			
145-150			
150-155			
155-160	.06	.6	3
160-165	0.2	1.5	9
165-170	0.4	2	17
170-175	0.8	2	29
175-180	0.7	1.4	60

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Fragmentation Test of 2875 Rocket Heads

TABLE II

FRAGMENT VELOCITY DATA

35mm Fastax Camera	3300 frames per sec.	
30.6 foot Radius Arena		
Rd. 1, 2875 AAFF Rocket	HBX-1 loaded	
Total Head Weight 6.30 lbs.	Filler Weight 1.4 lbs.	
Total Head and empty motor weight 10.30 lbs.		
<u>Frame in Which Hit Occurred</u>	<u>No. Fragments</u>	<u>Velocity (f/s)</u>
24	10	4210
25	9	4040
26	9	3880
27	10	3740
28	9	3610
29	5	3480
30	2	3370
31	2	3260
32	1	3160
33	2	3060
37	3	2730
38	2	2660
39	3	2590
40	2	2520
Median		3800
Average		3620

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NPC REPORT NO. 964

Fragmentation Test of 2875 Rocket Heads

TABLE II (Continued)

35mm Fastax Camera	3210 frames per sec.
30.6 foot Radius Arena	
Rd. 2, 2475 AAPF Rocket	HBX-1 loaded
Total Head Weight 6.30 lbs.	Filler Weight 1.4 lbs.
Total Head and empty motor weight. 10.30 lbs.	

<u>Frame in Which Hit Occurred</u>	<u>No. Fragments</u>	<u>Velocity (f/s)</u>
23	6	4270
24	14	4090
25	10	3930
26	13	3780
27	16	3640
28	6	3510
29	8	3390
30	5	3270
31	3	3170
34	1	2890
35	1	2810
36	1	2730
37	2	2650
38	2	2580
39	2	2520
41	1	2400
Median		3750
Average		3630
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NPG REPORT NO. 964

Fragmentation Test of 2875 Rocket Heads

TABLE II (Continued)

35mm Fastax Camera 3240 frames per sec.
30.6 foot Radius Arena
Rd. 3, 2875 AAFF Rocket HBX-1 loaded
Total Head Weight 6.30 lbs. Filler Weight 1.4 lbs.
Total Head and empty motor weight 10.30 lbs.

<u>Frame in Which Hit Occurred</u>	<u>No. Fragments</u>	<u>Velocity (f/s)</u>
23	7	4310
24	6	4130
25	3	3970
26	12	3810
27	11	3670
28	8	3540
29	6	3420
30	4	3300
31	1	3200
32	3	3100
33	1	3000
34	1	2920
36	2	2750
37	1	2680
38	2	2610
39	1	2540
Median		3780
Average		3610

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NFG REPORT NO. 964

Fragmentation Test of 2875 Rocket Heads

TABLE II (Continued)

35mm Pastax Camera	3270 frames per sec.	
30.5 foot Radius Arena		
Rd. 4, 2875 AAFF Rocket	HBX-1 loaded	
Total Head Weight 6.35 lbs.	Filler Weight 1.4 lbs.	
Total Head and empty motor weight 10.35 lbs.		
<u>Frame in Which</u> <u>Hit Occurred</u>	<u>No. Fragments</u>	<u>Velocity (f/s)</u>
23	1	4350
24	5	4170
25	7	4000
26	11	3850
27	15	3710
28	5	3570
29	5	3450
30	3	3340
31	2	3230
32	1	3130
36	2	2780
37	1	2700
42	2	2380
Median		3800
Average		3650

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Preparation Test of 2776 Rocket Head

NFO REPORT NO. 964

TABLE III

MASS DISTRIBUTION DATA

FRAGMENTATION OF 2776 ALUMINUM ROCKET HEAD AND MOTOR PRO 1033-37 (MOTOR EMPTY)

NUMBER AND WEIGHT OF RECOVERED FRAGMENTS										NUMBER AND WEIGHT OF RECOVERED FRAGMENTS													
HEAD	P111-0-0636 0.625-125 1.25-2.5 2.5-5			5-10			10-20			20-40			40-60			80-160			160-320				
Comp.	or	frame	frame	frame	frame	frame	frame	frame	frame	frame	frame	frame											
Rd.	Wt.	Wt.	Wt.	Wt.	Wt.	Wt.	Wt.	Wt.	Wt.	Wt.	Wt.	Wt.	Wt.	Wt.	Wt.	Wt.	Wt.	Wt.	Wt.	Wt.			
No.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.			
1	6.25	1.4	590	437	523	443	265	369	113	339	54	44	4	--	--	--	--	2456	1004	233	45		
2	6.30	1.4	633	423	517	419	255	409	120	251	39	96	6	--	--	--	--	2486	1007	256	68		
3	6.30	1.4	649	445	536	433	256	451	132	238	38	20	2	--	--	--	--	2507	1038	271	74		
4	6.30	1.4	656	438	515	494	298	421	128	190	33	11	1	--	--	--	--	2483	1072	273	97		
5	6.30	1.4	480	379	450	429	252	449	133	342	55	46	4	--	--	--	--	2397	978	272	84		
MOTOR																							
1	4.01	--	31	20	26	22	13	31	10	109	15	73	5	193	7	137	3	--	168	1	570	1	
2	4.00	--	20	32	41	37	22	61	14	110	17	149	10	136	4	294	6	83	1	--	421	1	
3	3.95	--	20	22	28	33	18	76	23	118	17	247	18	140	6	163	3	--	--	493	1	1312	114
4	4.00	--	27	21	26	27	15	38	11	59	10	61	5	146	5	434	8	--	--	537	1	1350	81
5	4.04	--	34	17	21	40	23	51	14	104	16	162	11	134	4	326	6	--	--	494	1	1362	96
AVERAGE																							
	6.29	1.4	602	424	508	442	265	420	125	272	44	43	4	--	--	--	--	--	2486	1020	261	74	
AVERAGE																							
	4.00	--	26	22	28	32	18	49	14	100	15	138	10	150	5	271	6	168	2	33.8	2		
																		503	1	1342	97		
																		--	--	--	--		

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APPENDIX D

FRAG NO. 1620

HEAD

0 - % Gms
590 Pcs.
Gms.

5/ - 1/4 Gms
523 Pcs.
437 Gms.

1/4 - 2 1/2 Gms
265 Pcs.
443 Gms.

2 1/2 - 5 Gms
113 Pcs.
369 Gms.
5 - 10 Gms
54 Pcs.
337 Gms.
10 - 20 Gms
4 Pcs.
44 Gms.
20 - 40 Gms
Pcs.
Gms.

40 - 80 Gms
Pcs.
Gms.

160 - 320 Gms
Pcs.
Gms.

320 - 640 Gms
Pcs.
Gms.

FUZE - FRAGS

45 Pcs
233 Gms

MOTOR

NP9-46986

31

25

20

13

22

10

36

15

104

5

73

193

3

151

118

570

1

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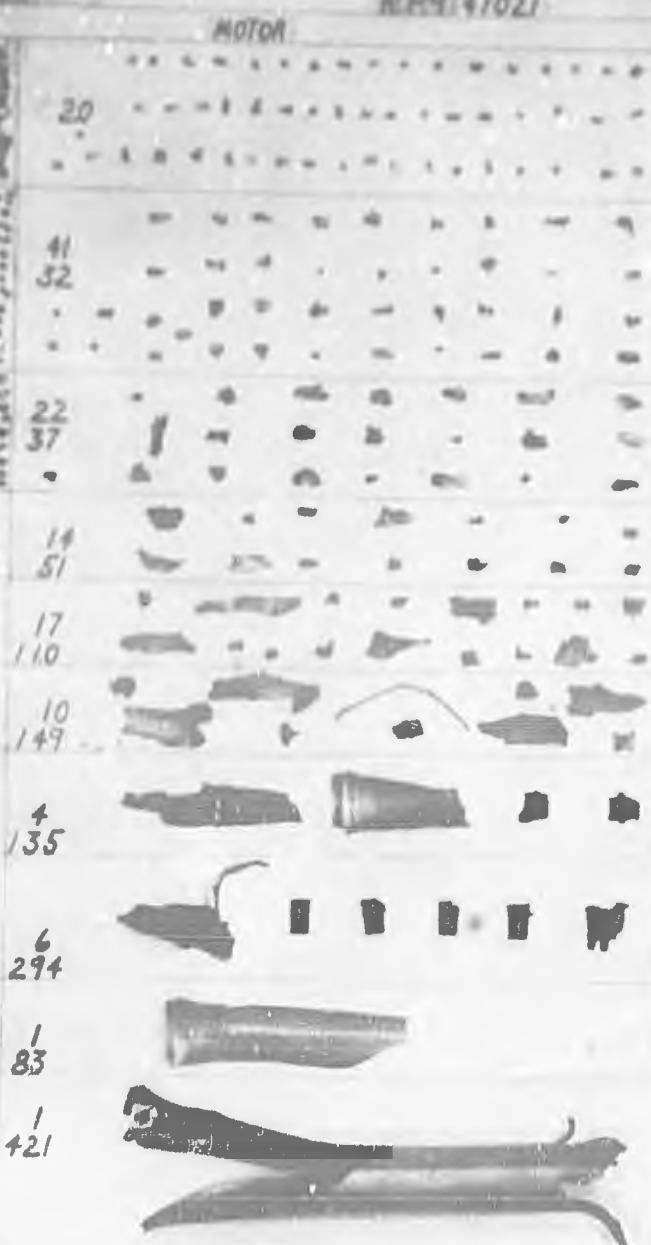
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FRAG NO. 1621

HEAD

NP9-47021

0 - 56	Gms.	
633	PCS.	
	Gms.	
5/8 - 1 1/2	Gms.	
517	PCS.	
423	Gms.	
1 1/2 - 2 1/2	Gms.	
255	PCS.	
419	Gms.	
2 1/2 - 5	Gms.	
120	PCS.	
109	Gms.	
5 - 10	Gms.	
39	PCS.	
251	Gms.	
10 - 20	Gms.	
8	PCS.	
95	Gms.	
20 - 40	Gms.	
	PCS.	
	Gms.	
40 - 80	Gms.	
	PCS.	
	Gms.	
80 - 160	Gms.	
	PCS.	
	Gms.	
320 - 640	Gms.	
	PCS.	
	Gms.	



FUZE - FRAGS

68 PCS.

Gms.

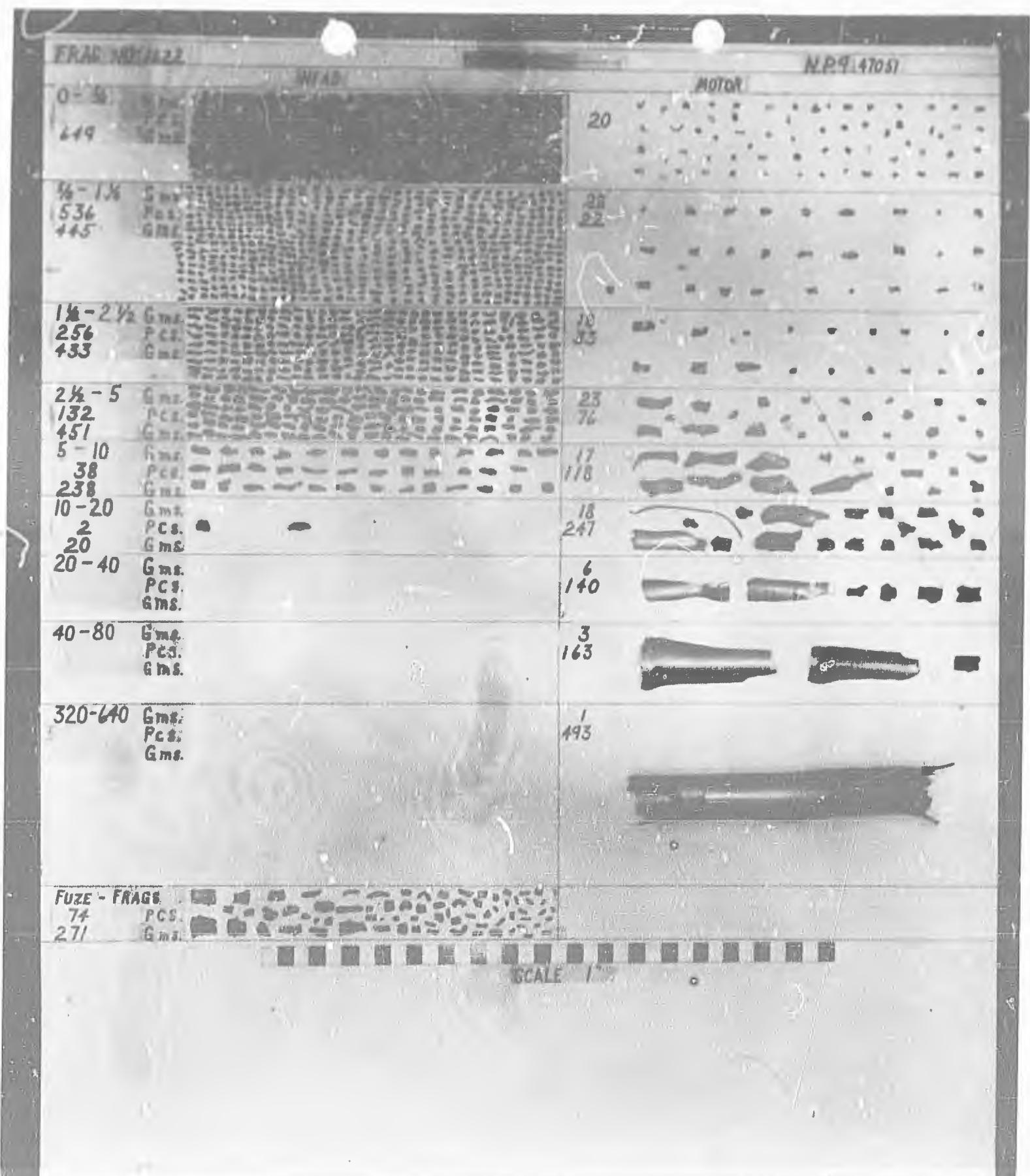
SCALE 1"

NP9-47021

14 DECEMBER 1951

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Round No. 2. Fragment Mass Distribution of HBX-1 loaded 2"75 AAFF Rocket.
Figure 4



NP9-47051

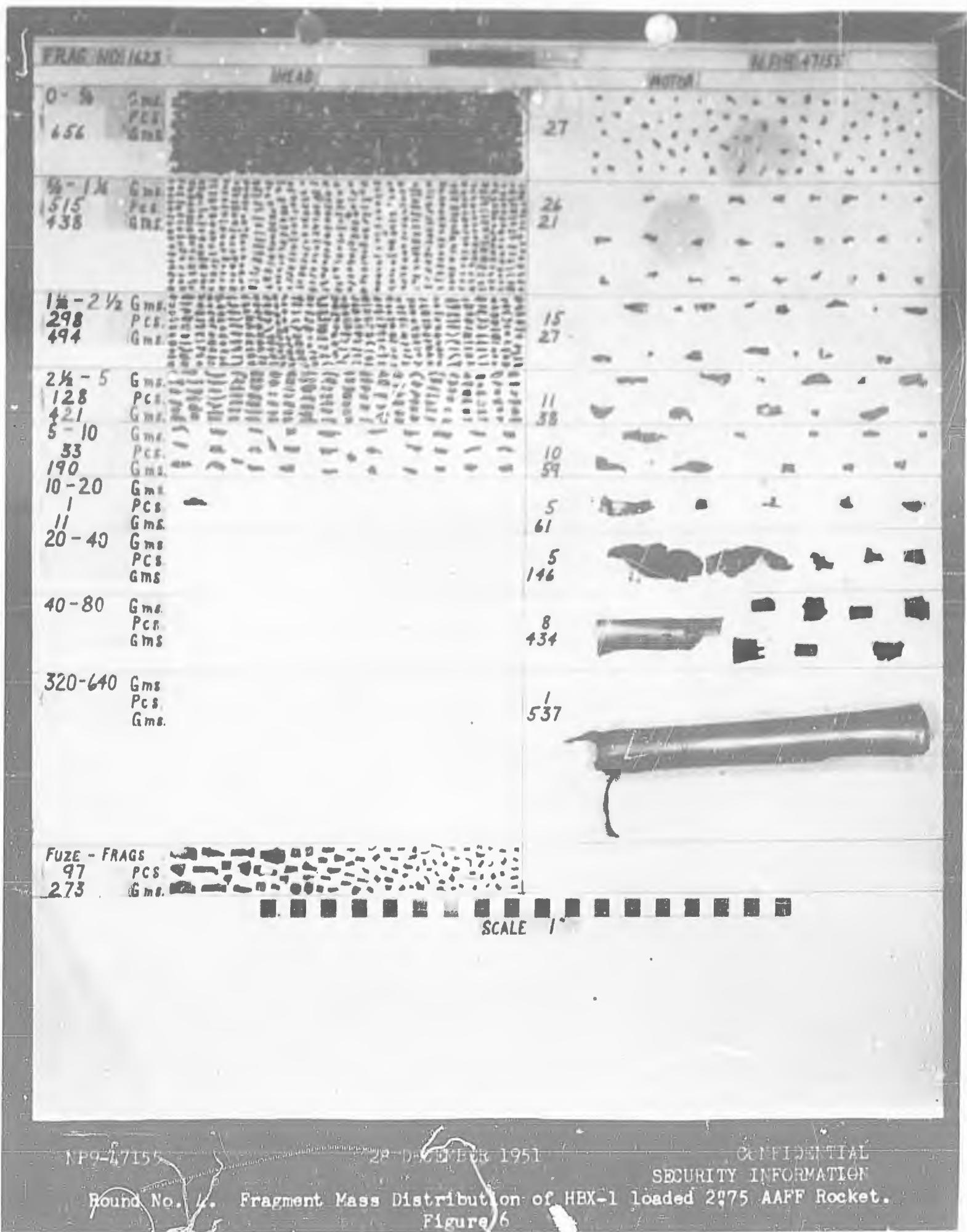
20 DECEMBER 1951

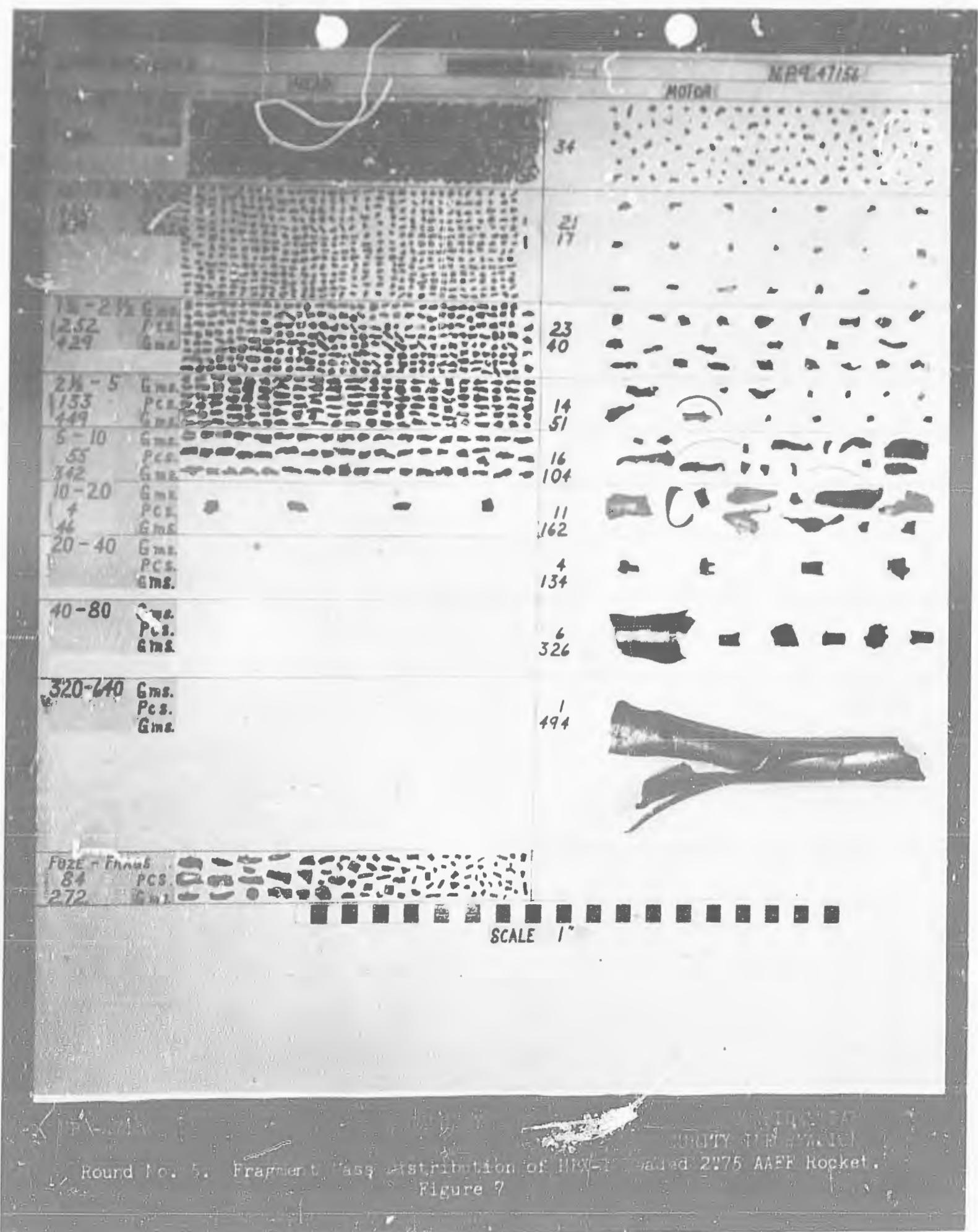
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Round No. 3. Fragment Mass Distribution of HBX-1 loaded 2.75 AAFF Rocket.

Figure 5





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NPG REPORT NO. 964

Fragmentation Test of 2875 Rocket Heads

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Library of Congress
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Development and Proof Services

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U. S. Atlantic Fleet, U. S. Naval Base
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Naval Ordnance Laboratory
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APPENDIX E

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NFO REPORT NO. 964

Fragmentation Test of 2075 Rocket Heads

DISTRIBUTION (Continued)

Inst. for Cooperative Research
JHU/1315 St. Paul St.
Via: (District Chief, Phila Ord District
1500 Chestnut St., Phila 2, Pa.
Attn: Mr. Edward R. C. Niles)

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Local: OT
OTZ
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APPENDIX E

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